Mahidol University *Wisdom of the Land*

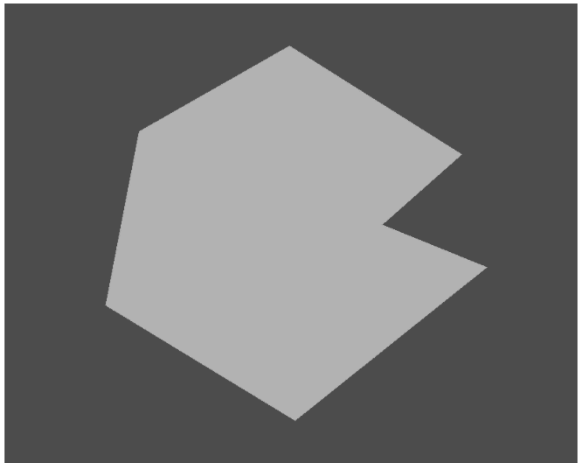
Chapter 7

Image Segmentation (Part2)

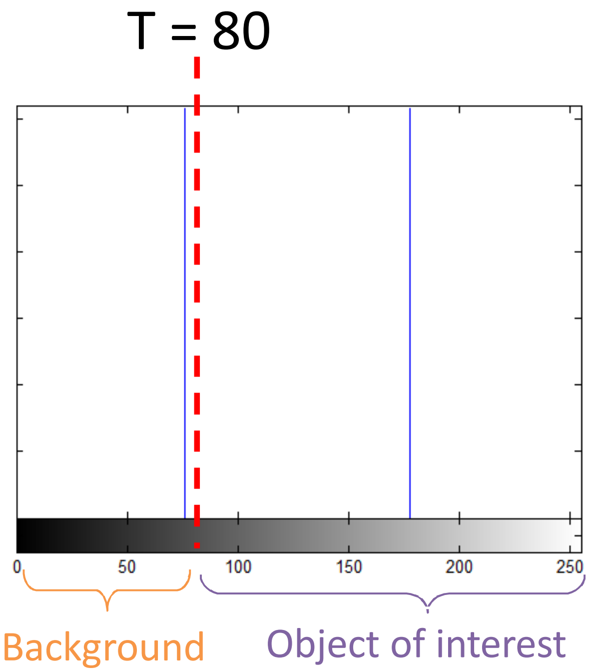
Thresholding

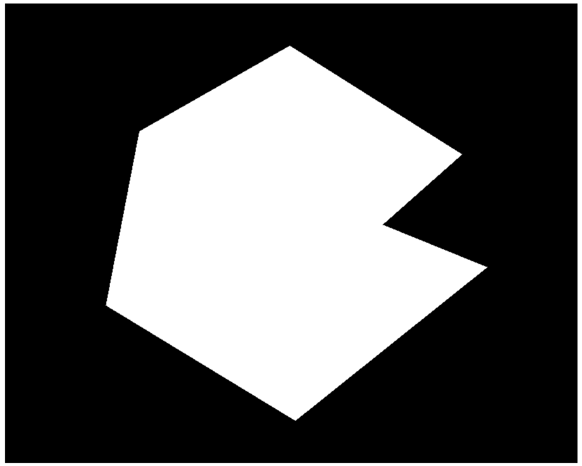
Original image
$f(x, y)$

Output Image
$g(x, y)$



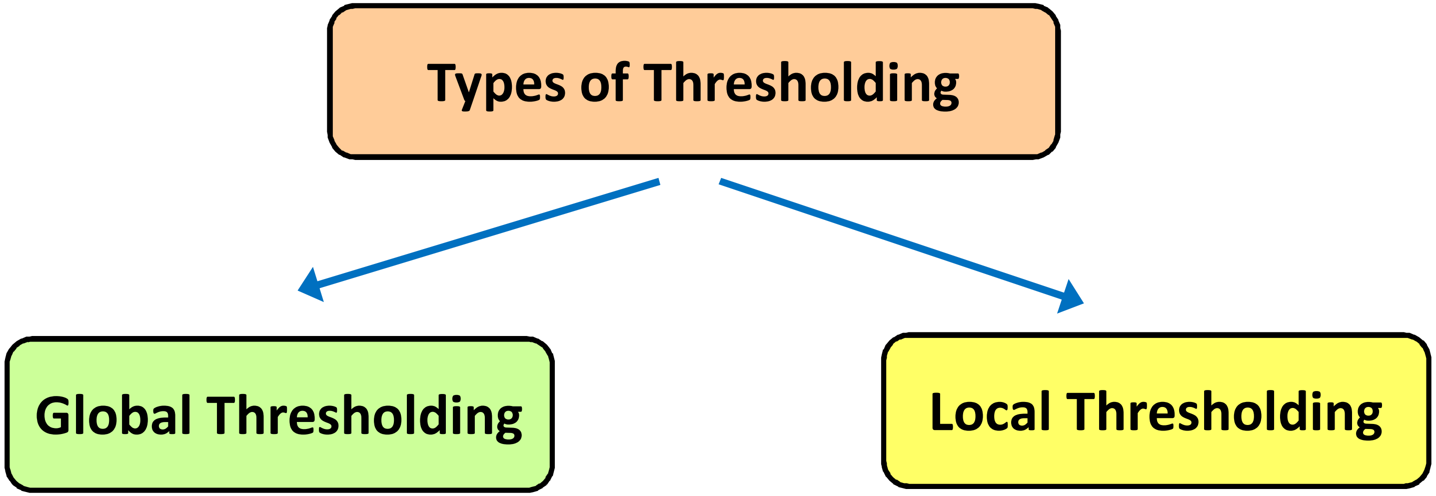
Original image





Threshold image

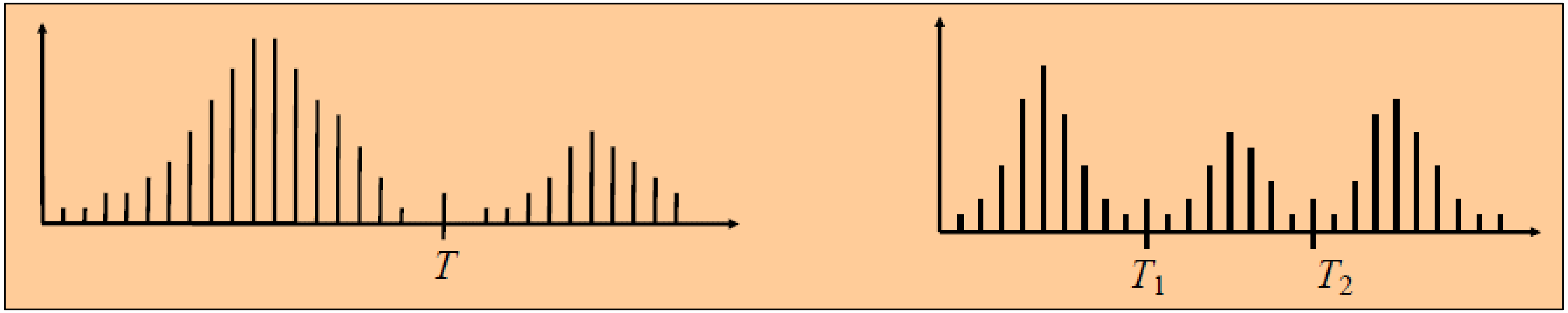
Thresholding



Global Thresholding

- Global Thresholding: setting threshold ***T*** in histogram to segment the object from background.
- Assumption: the range of intensity levels covered by objects of interest is different from the background.

$$g(x,y)=\begin{cases}1 & \text{if } f(x,y)>T\\ 0 & \text{if } f(x,y)\le T\end{cases}$$



Global Single Thresholding

Global Multiple Thresholding

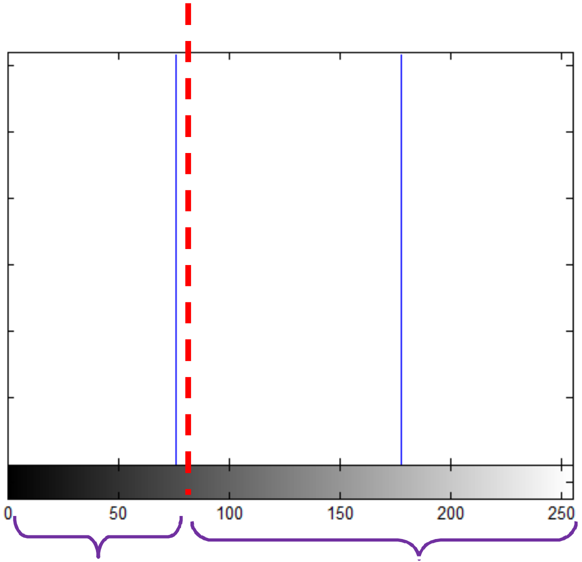
Example : Global Single Thresholding

$$g(x,y)=\begin{cases}1 & \text{if } f(x,y)>T\\ 0 & \text{if } f(x,y)\le T\end{cases}$$

$f(x,y)$

Original image

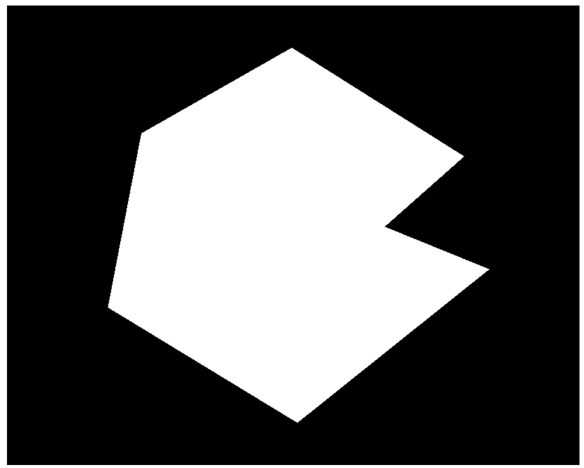
T = 80



Background

Object of interest

$g(x,y)$

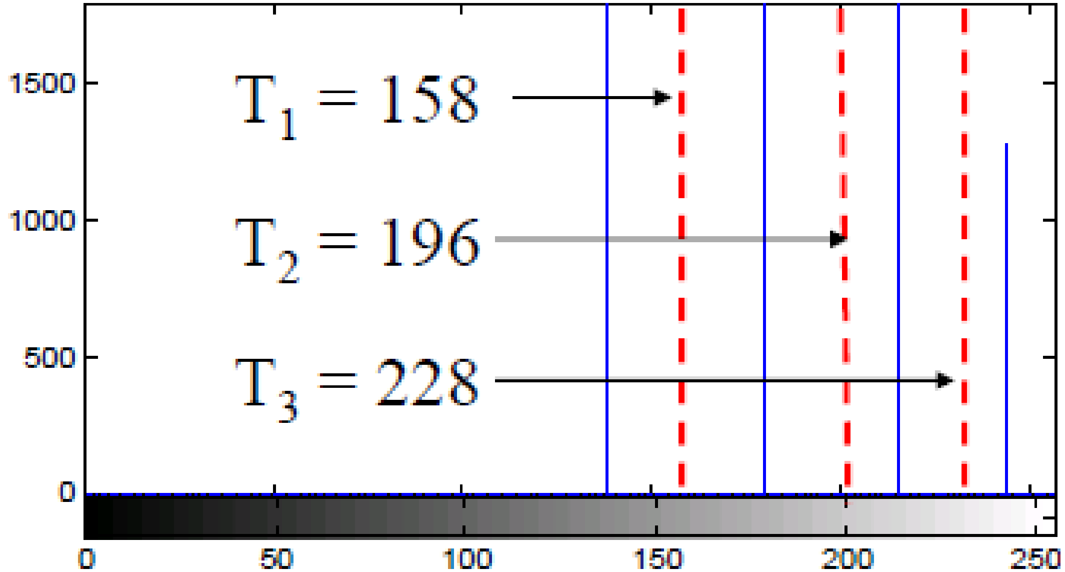


Threshold image

Example : Global Multiple Thresholding

Original image

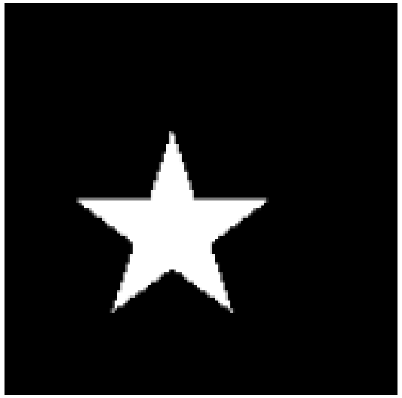
Histogram



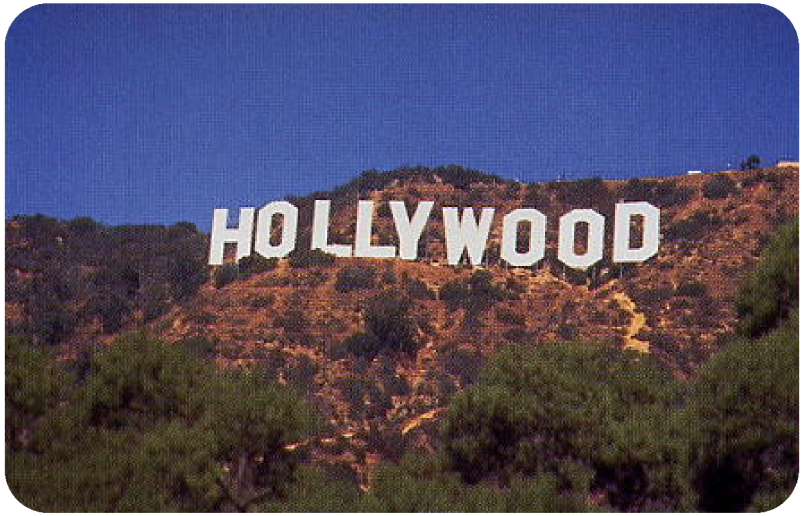
$T_1 < P < T_2$

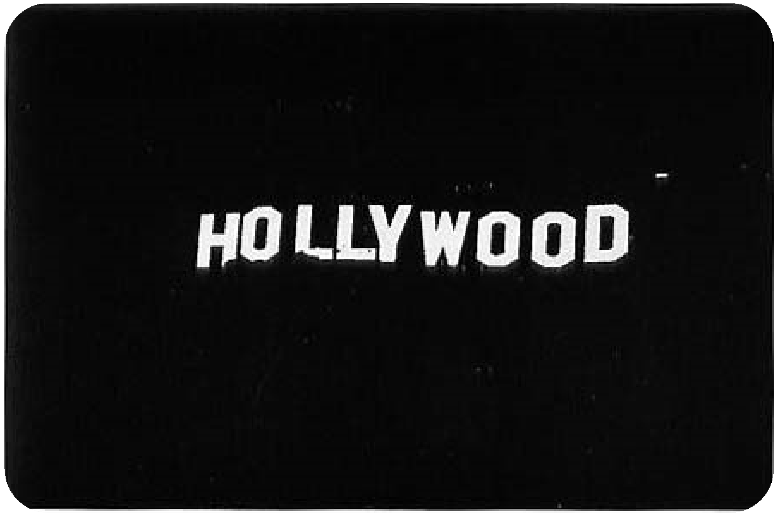
$T_2 < P < T_3$

$P > T_3$



Example : Global Single Thresholding

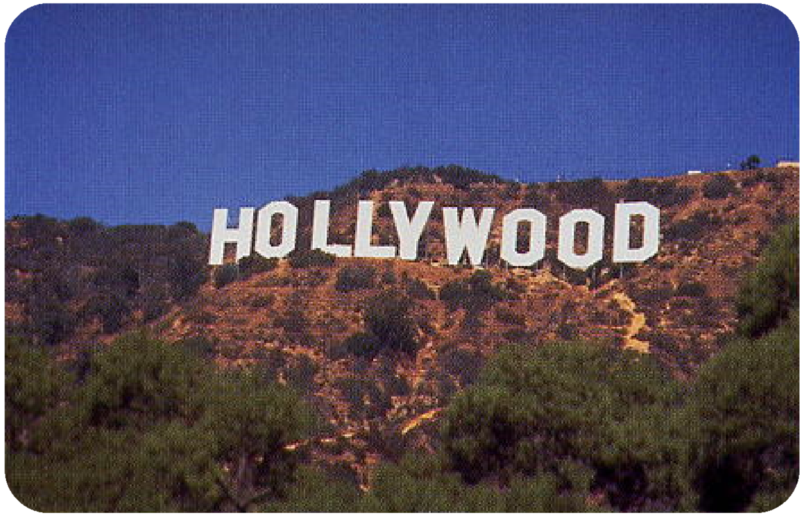


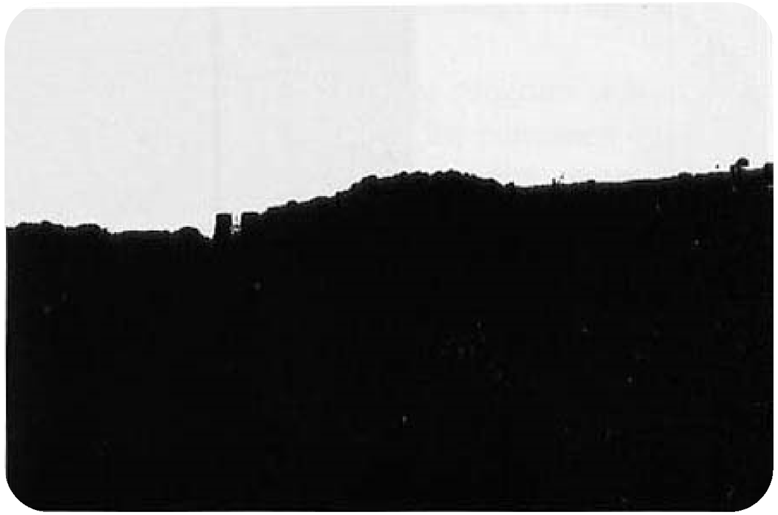


$$g(x,y)=\begin{cases}1 & f_R(x,y)\geq T_R, f_G(x,y)\geq T_G, f_B(x,y)\geq T_B\\ 0 & \text{otherwise}\end{cases}$$

$$T_R = T_G = T_B = 200$$

Example : Global Multiple Thresholding

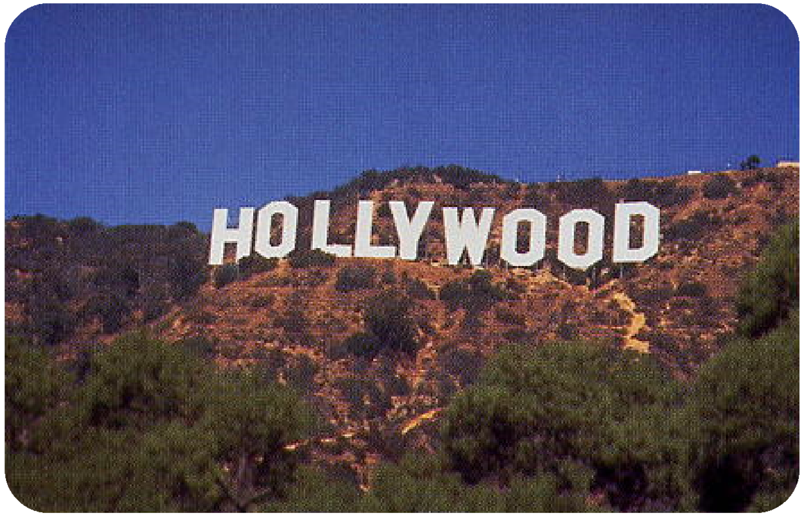




$$g(x,y)=\begin{cases} 1 & \begin{array}{l} T_{R1} \le f_R(x,y) \le T_{R2}, \\ T_{G1} \le f_G(x,y) \le T_{G2}, \\ T_{B2} \le f_B(x,y) \le T_{B2} \end{array} \\ 0 & \text{otherwise} \end{cases}$$

$$[T_{R1}, T_{R2}] = [50{,}100]$$
$$[T_{G1}, T_{G2}] = [100{,}150]$$
$$[T_{B1}, T_{B2}] = [150{,}200]$$

Example : Global Multiple Thresholding



$$g(x,y)=\begin{cases}1 & d(x,y)\le d_{MAX}\\ 0 & \text{otherwise}\end{cases}$$

$$d(x,y)=\sqrt{(f_R(x,y)-T_R)^2+(f_G(x,y)-T_G)^2+(f_B(x,y)-T_B)^2}$$

$$(T_R,T_G,T_B)=(80,100,50) \qquad d_{MAX}=50$$

Automatic Global Thresholding

- The major problem of intensity thresholding is to find a good threshold level.
- Global single thresholding algorithm.

1) Set initial value of T_0 , segment image to two regions.

2) $$\mu_1 = Average\left(p(x,y) \middle| p(x,y) > T\right)$$

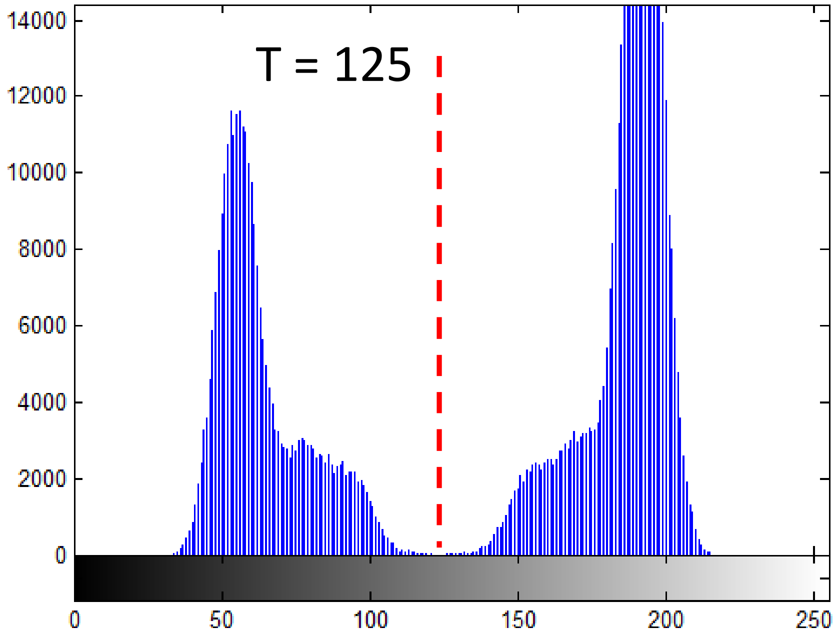
3) $$\mu_2 = Average\left(p(x,y) \middle| p(x,y) \le T\right)$$

4) $$T = \frac{\mu_1 + \mu_2}{2}$$

5) Repeat step 2 through 4 until the difference in *T* is smaller than a predefined T_0

Example : Global Thresholding

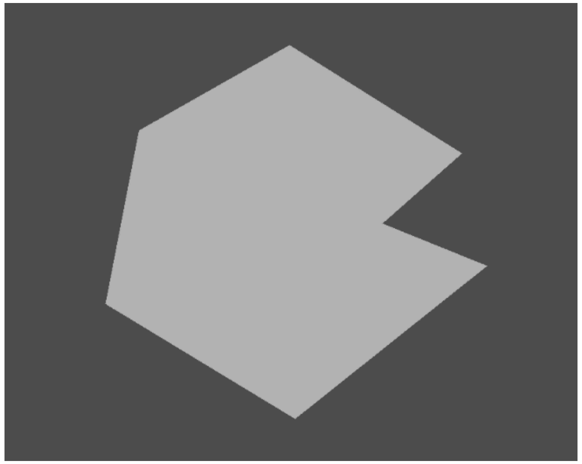
Original image

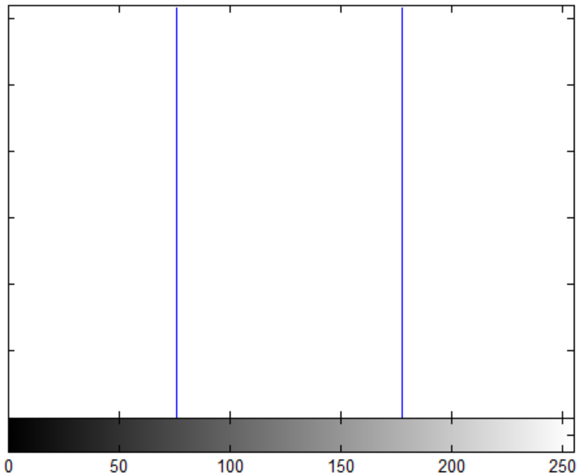


Histogram

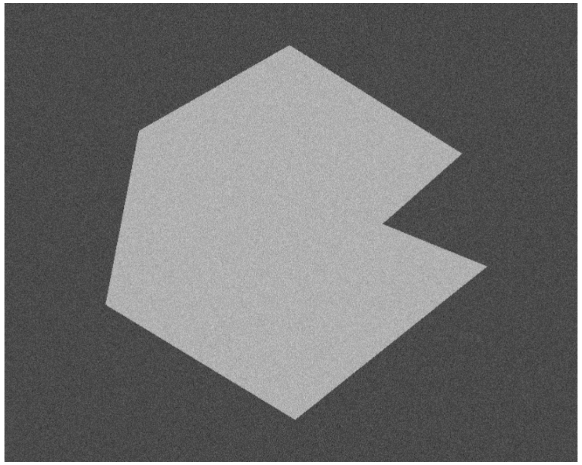
Threshold image

Noise Role in Thresholding





Original image



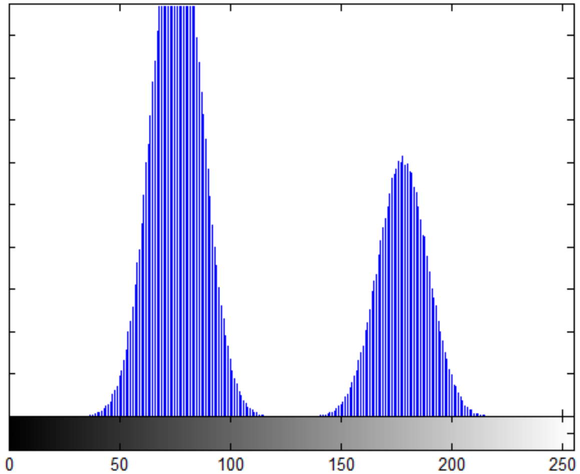
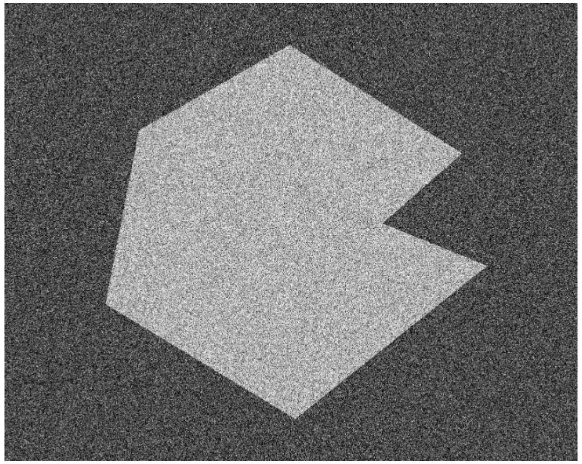


Image corrupted by Gaussian noise (σ=10)



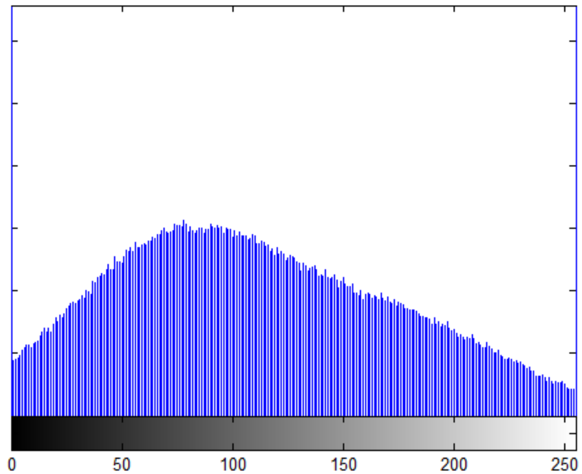
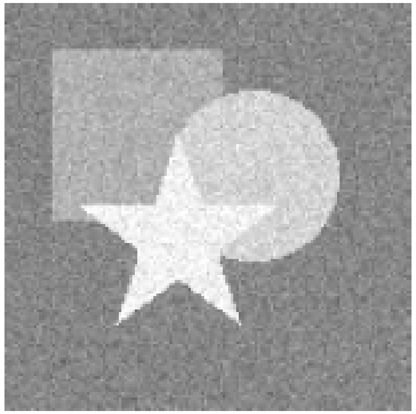
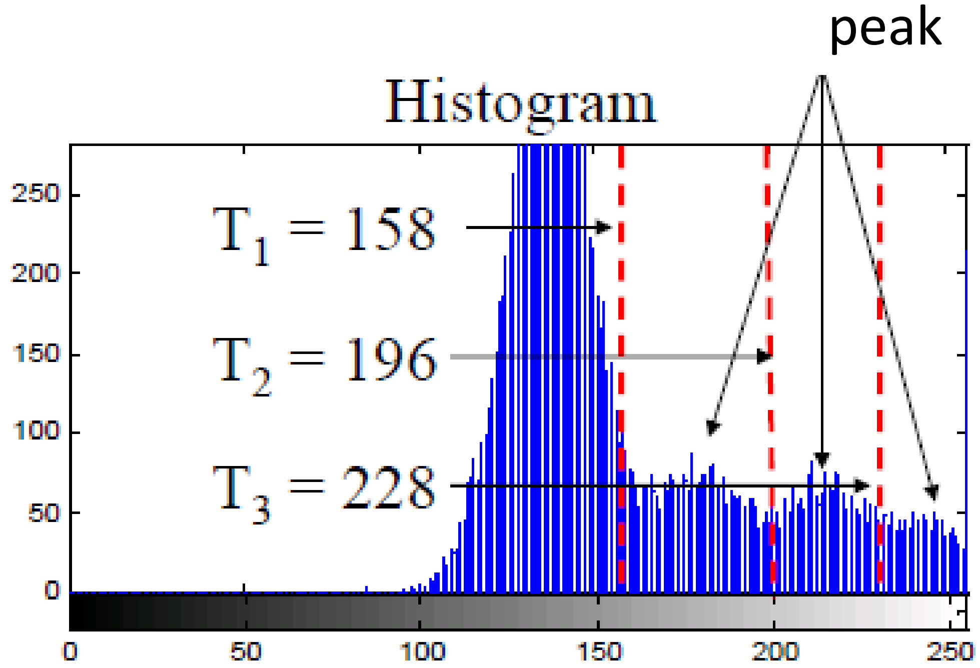


Image corrupted by Gaussian noise (σ=50)

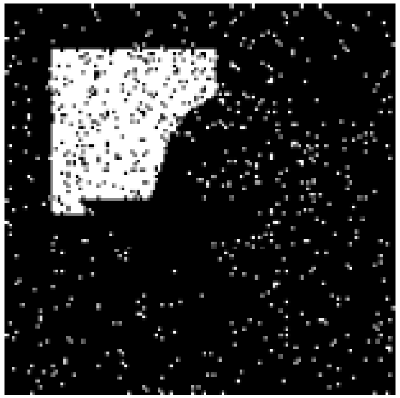
Example : Noise Role in Thresholding

Image degraded by Gaussian noise (σ=12)

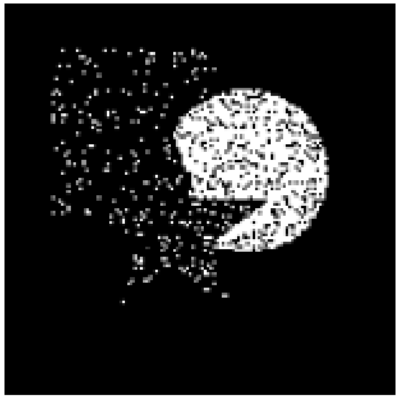




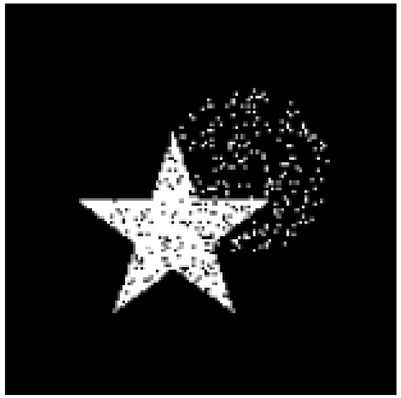
$T_1 < P < T_2$



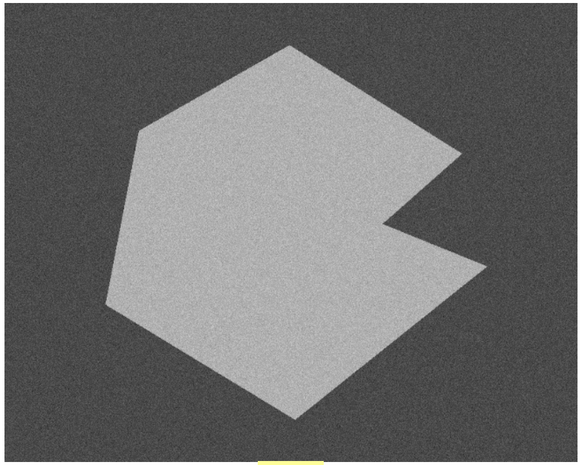
$T_2 < P < T_3$



$P > T_3$

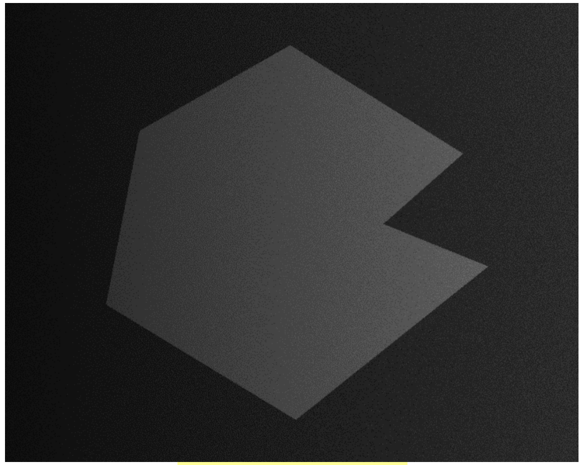


Illumination and Reflection Role in Thresholding



A

B



$C = A.B$

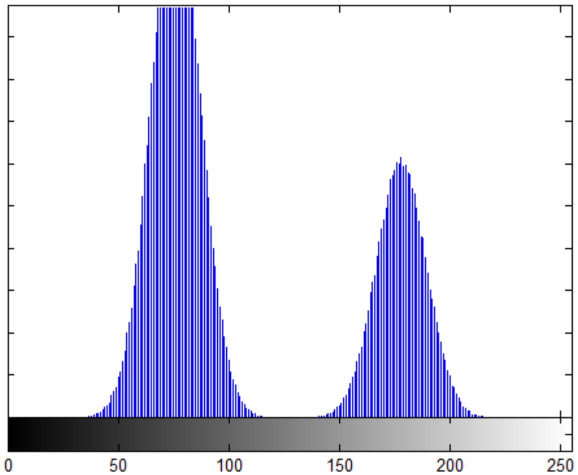


Image corrupted by
Gaussian noise (σ=10)

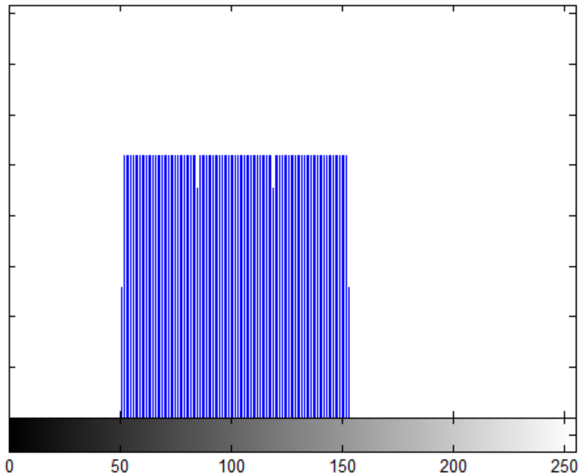


Image shading

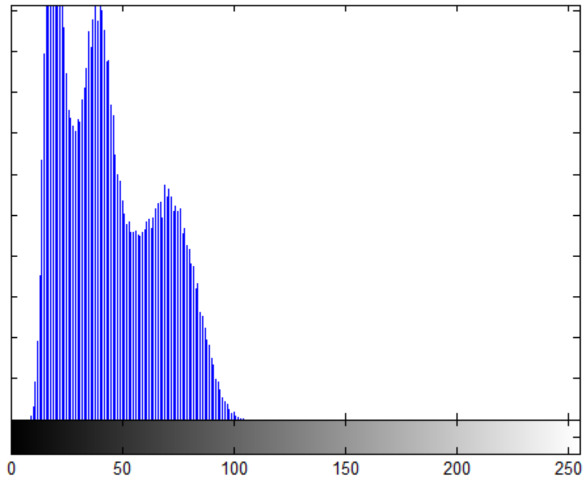
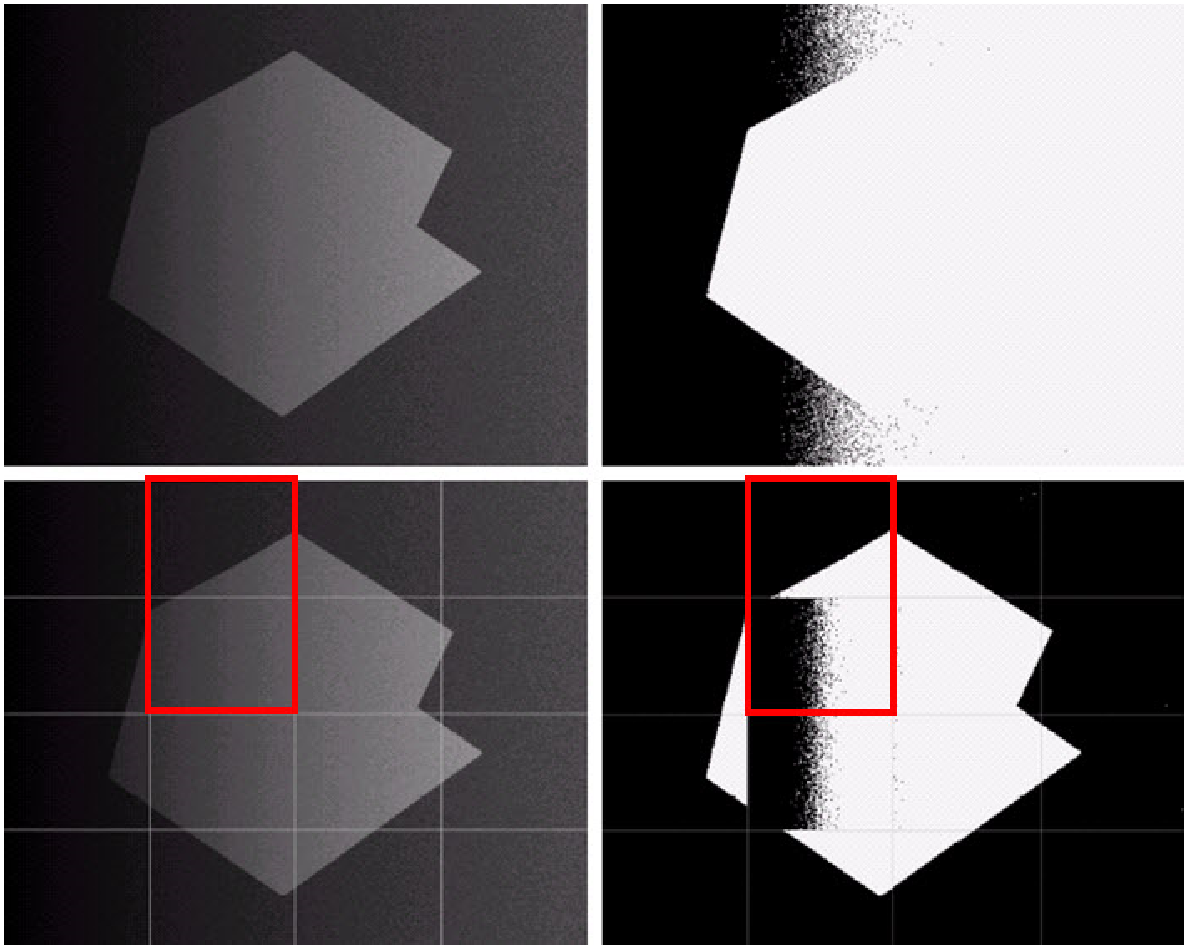


Image corrupted by
noise and shading

Illumination and Reflection Role in Thresholding

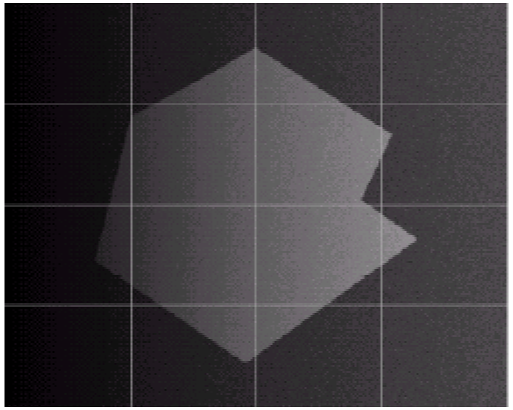
- Divide the image into sub-images and utilize a different threshold to segment each sub-image.

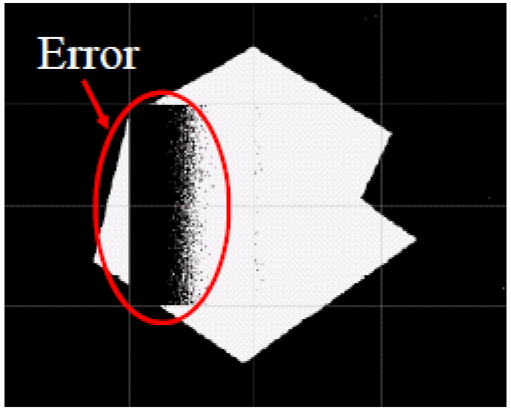


Nonuniform Illumination and Local Thresholding

- Local thresholding:
- 1) Divide an image into sub-images.
- 2) Threshold each sub-image independently
  - 2.1) Compute histogram of each sub-image and select a suitable threshold value for each sub-image
  - 2.2) threshold each sub-image using a threshold value in 2.1
  - 2.3) Combine all local thresholding results

16 sub-images



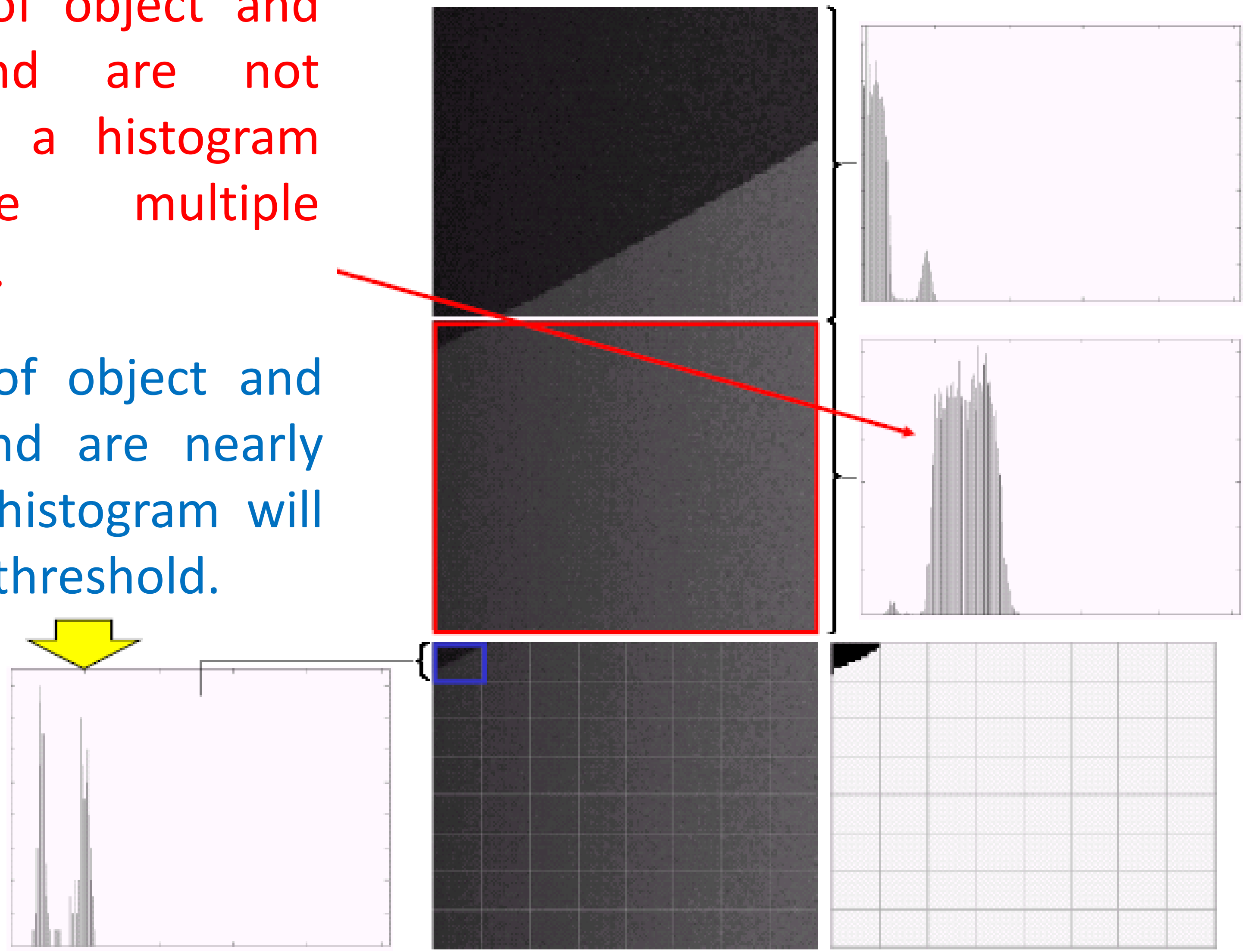


Result of local thresholding

Nonuniform Illumination and Local Thresholding

If areas of object and background are not balanced, a histogram will be multiple threshold.

If areas of object and background are nearly equal, a histogram will be single threshold.



Thanks for your attention